Electronics (EL)

Proposal Due Date: **June 13, 2007**

The National Science Foundation (NSF) Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) program seeks innovative state-of-the-art, high-risk, high-potential research proposals in wireless, electrical, photonic, micro-electronic and nano-electronic technologies. Applications of these technologies in the electronic marketplace can range widely in photonics, sensing systems, electro-optics, telecommunications, computation, integrated circuit design, quantum information processing, scientific and industrial instrumentation, robotics and control systems, advanced electronic materials, magnetics, micro- and nano-electro-mechanical systems, energy and power management, and micro- and nano-electronics manufacturing. The Electronics (EL) topic is grouped under **fifteen (15)** alphabetically designated subtopics. You must select a subtopic appropriate for the proposed research and enter its letter and number designation (e.g. A.3) in the subtopic box on the proposal cover page. Innovative electronic technologies that are not suggested explicitly in the subtopics below may still be of interest if they fall generally within one of the subtopics.

Proposals must address the potential for commercialization of the innovation and how it would lead ultimately to product sales. It is important that the proposed technology increase the competitive capability of the electronics industry, is responsive to societal needs, and is sensitive to solving “real” problems driven by critical market requirements.

NOTE:

1. Proposals that focus on topics such as software coding, protocols, computing architectures, etc. and if the final product is a software package or licensable software IP, are not appropriate for submission under the EL topic but should be submitted under the Information-based Technology (IT) topic in response to the IT topic solicitation.
2. Proposals that address processes associated with the manufacture of non-electronic materials, components, or systems should be submitted under the Advanced Materials (AM) topic in response to the AM topic solicitation at a future date.

Distinction between Electronics Topics and Emerging Opportunities topics

Some Electronics topics are also found in the Emerging Opportunities (Hardware) topic description. In cases where the innovation research addresses a topic found in both the Electronics topic and the Emerging Opportunities (Hardware) topic, a choice must be made as to where to submit the proposal. If the innovation research addresses a market opportunity within a three-year time horizon and has been significantly vetted with appropriate stakeholders, the proposal should be submitted to the Emerging Opportunities

(Hardware) topic. Proposals with longer-term commercialization potential or less vetting from significant stakeholders should be submitted to the Electronics topic.

A. Sensors

Recent technological advancements in materials science, micro fabrication of MEMS, and bioengineered systems have made inexpensive, powerful, and ubiquitous sensing a reality. Examples range from truly smart airframes and self-evaluating buildings and infrastructure for natural hazard mitigation to large-scale weather forecasting, self-organizing energy systems and smart devices that self-assemble into networks leading to the first electronic nervous system that connects the Internet back to the physical world. New detection technologies that overcome barriers of time, scale, materials and environment, and emphasize self-calibration, selectivity and sensitivity are required. Sensor networks that are ad hoc, multi-hop, robust, and low-power need further development. The convergence of the Internet, communications, nanotechnologies, advanced materials and information technologies with techniques for miniaturization has placed sensor technology at the threshold of a period of major growth. Wearable electronics and associated medical applications will make a large impact on remote patient bio-monitoring and bio-chemical detection. Speed, robustness, fewer false alarms, and the ability to function unattended and autonomously in unusual, extreme, and complex environments will be required. Industry needs to develop nano-templates as nano-manufacturing tools for nano-devices and sensors as a bare minimum before nanotechnology can flourish. Ways must be found to effectively integrate sensing device, actuators and computation into working micro-systems with the associated front-end electronics. Items of interest include but are not limited to:

A.1 Sensors for smart transportation and infrastructure

A.2 Micropower wireless/ autonomous sensing and networking

A.3 Actuators to enhance sensor performance

A.4 Sensors for life sciences, medical applications and systems

A.5 Noninvasive medical devices

A.6 Bioassay instrumentation

A.7 Gas phase and liquid phase sensing

A.8 Environmental sensing

A.9 Integrating performance standards for calibration (e.g. resistance, time, voltage)

A.10 Process control

A.11 Non-Destructive Testing and Evaluation systems

A.12 Remote sensing sensors and systems

A.13 Detection of and countermeasures to Improvised Explosive Devices (IEDs) using for example autonomous, remote sensing and search technologies

B. Wireless Technologies

Wireless will become massive in its pervasiveness, and impact virtually every aspect of life evolving well beyond mobile phones and PDAs to other devices, services, channels and content. Microwave circuits afford more frequency spectrum and very short antennas. With GaAs and SiGe, entire microwave transceivers can be inexpensively put on a single chip. New modulation methods, like spread-spectrum and orthogonal frequency-division multiplexing, bring greater spectral efficiency and more bits/Hz of bandwidth, and lead to less susceptibility to noise, interference, and multi-path distortion. On-chip DSPs allow new signal-processing functions. New RFID chips are revolutionizing warehousing, materials handling, and shipping operations, replacing bar-code labels in many areas. Proposals that involve next generation wireless communication technologies requiring systems with high data rates, low cost, and that support a wide variety of applications and services, while maintaining full mobility, minimum latency, and long battery life, but not limited to the following areas are sought.

B.1 Medical device applications

B.2 Wireless surveillance

B.3 Secure (privacy; data) wireless communications

B.4 RFID

B.5 Wireless sensor networks

B.6 Personal area networks

B.7 Bandwidth efficient techniques

B.8 UWB systems

B.9 SDR architecture and hardware

B.10 Smart antenna systems

B.11 RF component and device design

C. Integrated Circuit (IC) Design

Nanometer design is becoming a reality, but its ultimate success hinges on the development of a very different design methodology. The continuing growth of electronic technologies beyond the fundamental physical limits in scaling electronic devices to smaller and smaller sizes has sparked unprecedented interests in atomic-scale design in gigascale electronics, integrated circuits and architectures. To that end, the EDA industry continues to pull together the pieces for a collective move to design at levels of abstraction higher than the register transfer level (RTL). At nanometer geometries, that gate-level netlist just doesn't carry enough information when the design is physically implemented to make it feasible. Design at the system level can help speed architectural exploration and system partitioning. At geometries of 100 nm and below, timing closure hinges on delay calculations. Interconnect delays rather than gate delays dominate calculations. Even at high levels of abstraction, the availability of a virtual prototype provides a basis in reality to which layers of deepening physical detail can be added throughout the design process. Nanometer design still brings a host of verification challenges. Mixed-signal verification must evolve to embrace the simultaneous modeling of digital circuits at high levels of abstraction and the analog and mixed-signal portions at the transistor level to improve efficiency. The widening gap between silicon capacity and design productivity is related to a number of factors, including hardware-software co-verification, IP reuse and integration, physical design, design for manufacturability (DFM), interconnects, noise sensitivity, power, and thermal solutions. Items of interest include but are not limited to:

C.1 Ultra low power circuits and architectures

C.2 High speed ADC/DAC

C.3 Novel chip architectures

C.4 Test techniques to improve design, development and manufacturability and reliability of microcircuits

C.5 On-chip circuitry for self-test, circuitry for characterization, external circuits for testing aids, etc.

C.6 Integration of nano- to micro-scale devices on circuits

C.7 Neuromorphic and other functional devices/circuits

C.8 Frequency references and other timing related circuits

C.9 Physics based models for CAD support

C.10 ICs with heterogeneous materials and devices

D. Innovative Uses of Light

Proposals are solicited for projects involving innovative uses of light, for market applications having the potential for significant economic impact and/or societal benefit. The key focus of this subtopic is on the novel aspects of generating, processing, detecting, imaging, and converting light in such a way as to result in disruptive new products, and breakthrough product improvements in the marketplace. Application areas of particular interest include: Energy, Biotechnology/Biomedical, Communications, Computing, Detection/Sensing and Analysis, Manufacturing Technology, Illumination and Consumer products.

	Application/Function	Light Generation	Light Conversion	Light Management	Light detection/analysis	Imaging & Display	System Integration, thermal mgt	Innovative Technologies
		1	2	3	4	5	6	7
a	Energy							
b	Biotechnology/biomedical							
c	Communications							
d	Computing							
e	Detection/sensing & analysis							
f	Manufacturing technology							
g	Illumination							
h	Consumer products							

D.1 Light Generation: Light sources for applications such as optical data storage, communications and displays. OLEDs and quantum devices based on CdS and ZnS to be used as light sources with enhanced quantum efficiency

D.2 Light Conversion: Solid state and organic photon detectors, quantum wells and dots, solar cells, light amplification and photo-chemical processes

D.3 Light Management: Materials, devices, and issues for manipulating light: e.g., electro-optic devices, photonic crystals, waveguides, optical mode and wavelength converters, optical resonators and delay lines, fiber and semiconductor optical amplifiers, short-wavelength mirrors, negative refractive index materials and devices, micro-lenses and solar concentrators

D.4 Light Detection/Analysis: Silicon based detectors, detector development in the visible and also in the IR. UV/Deep UV applications, II-VI based materials like ZnS and CdSe. HgCdTe (MCT'S), SiC, GaN and AlGaN based alloys

D.5 Imaging and Display: Novel possibilities using advanced technologies in small, medium, and large size displays which are brighter, consume low power, take less space, can be flexible, and are far more reliable

D.6 Systems Integration, Thermal Management: Hybrid systems integrating multiple innovative uses of light, including such combinations as photonics, electronics and magnetics to achieve increased functionality or enhanced performance; use of photons for active cooling or thermal management; innovative optical packaging techniques, such as photonic crystals

D.7 Innovative Technologies: Innovative ways of using and generating light not otherwise encompassed within the categories outlined above

E. Innovations in MEMS and NEMS Devices and Systems

Proposals are solicited for projects involving innovations in Micro Electro-Mechanical Systems (MEMS) and Nano Electro-Mechanical Systems (NEMS) for market applications having the potential for significant economic impact and/or societal benefit. The key focus of this topic is on the novel aspects of design, fabrication, and usage of MEMS and NEMS devices and systems, in such as way as to result in disruptive new products and breakthrough product improvements in the marketplace. Application areas of particular interest include: Electronics, Biotechnology/Biomedical, Micro-fluidics, Communications, Data Storage, Detection/Monitoring and Analysis, Manufacturing Technology and Imaging.

	Application/Innovation	Sensors 1	Actuators 2	Optical 3	Micro and nanomachines 4	Integrated systems 5	MEMS design, processing, packaging, materials 6	Innovative Technologies 7
a	Electronics							
b	Biotechnology/biomedical							
c	Microfluidics							
d	Communications							
e	Data storage							
f	Detection, monitoring & analysis							
g	Manufacturing technology							
h	Imaging							

E.1 Sensors: Accelerometers, fluid flow measurement devices, combustion sensors, gyroscopic guidance systems, bio-analytic sensors, etc.

E.2 Actuators: Devices that respond to changes in their environment causing another device to turn on, turn off, adjusted or moved

E.3 Optical: Switches, lens arrays, beam splitters, corrective optics, etc.

E.4 Micro- and Nano-Machines:

E.5 Integrated Systems: Materials, devices, and issues for integration of MEMs (e.g., sensors, actuators, micro-fluidics) with electronic and photonic circuits (e.g., CMOS, waveguides). Includes innovations in packaging and thermal management

E.6 MEMS design, processing, packaging, materials:

E.7 Innovative Technologies: Innovative ways of using and generating light not otherwise encompassed within the categories outlined above

F. Energy and Power Management

In the power electronics realm, as CMOS chips go to finer lithography with each new generation, their multiplying transistors require lower and lower voltages and higher and higher currents. These trends have driven up power demands on pc boards and placed constant pressure on power-supply and power-system developers to increase the efficiency and power or current density of their supplies. At the same time, the trends toward lower voltages and higher currents have encouraged migration from centralized to distributed and portable power architectures. Newer chips with lower supply-voltage requirements has greatly complicated power-system and power-supply design. The spread of the intermediate voltage bus architecture has spurred innovative developments in isolated and non-isolated dc-dc converters. In portable applications, some of the recent semiconductor developments provide equipment designers with the extra firepower needed to add functionality, in light of the critical need for efficient power management techniques. At the system level, new energy storage technologies such as new battery chemistries, fuel cells, and flywheels could make a tremendous impact on system reliability and energy usage. Ongoing challenges at all scale levels in national and global energy needs are placing increasing demands for innovative alternative energy strategies that require a broad vision in a variety of areas including distributed controls and adaptive dynamic power flow for managing intelligent power grids of the future from the device to the system level. Proposals are solicited on:

F.1 New energy sources for portable and mobile devices

F.2 Energy scavenging/harvesting for portable/remote devices

F.3 Systems for harvesting alternate energy sources

F.4 Smart power demand-response management systems, e.g. smart grids, buildings, circuits

F.5 Inverters, motors and generators for higher efficiency, smaller size and power factor corrections

F.6 Efficient and compact energy conversion systems for non-grid applications

F.7 New energy storage technologies

G. Geosciences Instrumentation

NSF/SBIR seeks proposals to design, develop, and prototype innovative sensors, devices and instruments for the scientific understanding of the integrated Earth systems, and that lead to an improved understanding of the factors that define and influence the Earth’s environment and planetary processes. Ozone levels, coal mine safety, radiation levels, seismic sensing, and oil exploration. Items of interest include but are not limited to:

G.1 Instruments addressing environmental monitoring in geophysical, atmospheric, and oceanographic phenomena

G.2 Devices for physical measurements at the Earth's surface and in boreholes beneath the surface

G.3 Instruments for measurement of atmospheric parameters, such as temperature, pressure, water vapor, and radiation

G.4 Instrumentation for research in the world's oceans, lakes and seas, polar icecaps and remotely operated geosciences instruments

H. Astronomical Instrumentation

Proposals that lead to new instruments and devices are solicited for astronomical observations in the radio, sub-millimeter, infrared, and optical wavelengths. Items of interest include but are not limited to:

H.1 Adaptive optics, wave front sensors, innovative focal plane technology, and lasers for artificial guide stars

H.2 Holographic gratings for dispersing elements and imaging Fourier transform spectrometers

H.3 Large diameter, broadband filters having low focal ratio number and uniform antireflection coatings

H.4 Heterodyne imaging spectrometers, with channel-independent auto-correlation, high resolution and large spectral coverage

H.5 Low-cost analog/digital converter chips for radio astronomy with high sampling rates and precision

I. Robotics

Challenges such as voice, obstacle and image recognition, emotional response, and eye-hand coordination still remain. High-performance processors, hardware to provide situational awareness, and improved artificial intelligence (AI) are enabling researchers to create lifelike robots that run or have facial expressions. High intelligence is a missing ingredient. Considerable progress will be made if robots possessed the intelligence needed to cope with uncertainty, learn from experience and work as a team. Robot designers are borrowing features from insect nervous systems to build six-legged robots. Engineers and computer scientists cooperate with biologists, neuroscientists and psychologists to exploit new knowledge in the study of the brain and behavior. Some robots will help people do what they can't or would rather not do. Other robots will tackle complex projects by working as teams. Robots will help protect critical infrastructure and monitor the environment as mobile, intelligent sensors. Proposals involving robotics and intelligent machines having complex, human-like behavior are sought but not limited to:

I.1 Novel and advanced approaches to sensing, perception, and actuation including embedded and highly distributed systems

I.2 Applications to manufacturing

I.3 Systems to extend human capabilities into unknown and hazardous environments - underwater, search-and-rescue, security, and agriculture; wheeled and legged machines capable of exploring planets; unmanned aerial vehicles for surveillance and combat

I.4 Medical devices that provide new capabilities to doctors including surgery; robotic exoskeletons to enhance human strength; personal robots with an emphasis on human-centered end use and interaction, increased autonomy; robots of augmentation

I.5 Intelligent control architecture for robotic systems; development of human-robot interfaces; communication and task sharing between humans and machines, and among machines; self-diagnosing, self-repairing robots

J. Semiconductor and Other Materials

Proposals are solicited for advanced materials with potential for improved utility in micro- and nano- electronic devices, and in micro- and nano-magnetics. These materials include those used in mainstream integrated circuits such as silicon and compound semiconductors, high-k and low-k dielectrics, Silicon-On-Insulator (SOI) materials, nano-structured materials, molecular electronics, organic electronics and spin electronics. Other materials include those relevant to flat panel displays, semiconductors for microwave and radio applications, and materials for opto-electronics applications, including optical computing, communications, and mass storage. Proposals are invited for the improvement in performance of the following semiconductor and other materials:

J.1 Advanced silicon materials

J.2 Compound semiconductors

J.3 Photonic materials and crystals

J.4 Thin film and metallized materials

J.5 High temperature, high power, high frequency materials

J.6 Encapsulation materials; Heat sink materials

J.7 Superconductors

J.8 Self-assembled and other polymers

J.9 Dielectrics and nitride compounds

J.10 Magnetic materials

K. Nanoelectronics, Nanophotonics and Nanomagnetics

It is anticipated that nanotechnology through development of new classes of devices will provide significant performance increases in speed, power consumption, sensitivity and device density. Examples are nanotubes and nanowire based devices; single electron devices, nanomagnetics, molecular and spintronics; and quantum dot detectors and quantum computing devices. Proposals on integration of semiconductor, magnetic and photonic nanodevices as well as molecular, biological, mechanical, fluidic devices into functional circuits and devices are encouraged. Proposals are solicited in the general areas of:

K.1 Nanoelectronics - silicon nanoelectronics; beyond silicon - nanotubes, nanowires, molecular electronics

K.2 Nanophotonics – Very Large Scale Integrated (VLSI) photonics, photonic crystals, quantum dots, VCSELS, nonlinear optical devices

K. 3 Nanomagnetics/spintronics – Giant Magneto-Resistive (GMR) systems, Magnetic Random Access Memory (MRAM), quantum computing

L. Organic Electronics

Organic functional materials have the potential to be key enablers for novel photonic, electronic and optoelectronic device applications. Proposals that involve novel synthesis of these materials and methods of fabricating applications such as flat panel displays, solid state lighting, photovoltaics, and optical devices involving nonlinear optics are encouraged. Proposals are solicited in the general areas of:

L.1 Organic Light Emitting Diodes (OLEDs)

L.2 Organic based transistors

L.3 Organic photovoltaics (solar cells)

L.4 Organic memory for data storage applications

M. Semiconductor Manufacturing

Proposals are sought in areas that relate to electronics manufacturing. For innovative research proposals that would either retrofit or displace existing manufacturing techniques and processes, we strongly recommend that you provide supportive letters from manufacturing end-users with your proposal. Proposals are invited for approaches that improve the performance of semiconductor manufacturing in the following:

<u>Front End Processing</u>

M.1 Wafer production - crystal growth, wafer slicing, grinding and polishing

M.2 Thermal oxidation - silicon dioxide growth, furnace technology

M.3 Photomask creation - CAD design, pattern generation, photo-resist materials

M.4 Photolithography - ultraviolet, x-ray lithography, electron beam systems

M.5 Etching and doping - wet & dry etching; ion implementation, diffusion techniques

M.6 Chemical Vapor Deposition (CVD) – poly-silicon, silicon dioxide, silicon nitride Layers for barriers and circuits

M.7 Interconnects and contacts - sputtering, evaporation processes, Chemical Mechanical Polishing (CMP)

<u>Back-End Processing</u>

M.8 Testing and separation - die testing and probing, diamond sawing

M.9 Attachment, wire-bonding and packaging - die attach and bonding, thermo-sonic wire-bonding, encapsulation, chip packages, tape automated bonding, flip chip, silicon in chip packaging - Silicon in Package (SiP)

N. Nano-electronics Manufacturing

Proposals are solicited in techniques of nanoelectronics manufacturing including various forms:

N.1 Nanolithography and nanoimprinting

N.2 Material growth and deposition techniques

N.3 Self- assembly techniques

N.4 Quantum dots manufacturing

N.5 Large scale production of carbon nanotubes

N.6 Nanofabrication of electronic devices

O. Micro-electronics Packaging & Systems Integration

Proposals are solicited on more efficient means of integrating semiconductor components and devices into systems. The growth in chip density, coupled with the demand for high performance, small size, light weight, and affordable reliability has placed enormous pressure on interconnect technology and packaging at all levels. Proposals are solicited in improved techniques for interconnect and packaging at the board level, packaging approaches for the board components, the passive components, techniques for board assembly and finally, applications of techniques to packaging and systems integration for optoelectronics, RF Systems and MEMS.

O.1 Printed Wiring Board Manufacturing - Board materials; Board preparation; Hole drilling, punching and plating; Circuit lithography (CAD tools); Solder masks; Multiplayer board fabrication

O.2 Single Chip Packages for improved performance and reliability in single and Multiple-chip packaging particularly thermal performance, of the following types: Through–hole; Surface mount; Area arrays (Ball Grid Array, Quad Flat Pack, etc.); Multichip modules

O.3 Passive Components - Methods for improving the performance of reliability of passives (capacitors, inductors, resistors) on the Printed Wiring Board with respect to: Discrete components; Integrated components; Embedded and on chip passive components

O.4 Board Assembly - Improved methods for board assembly in: Surface Mount Assembly including lead free soldering; Thick Film processing for ceramic components/ Hybrid systems; Thin Film processing using PVD and CVD techniques; Testing, Inspection and Measurement; Environmentally Benign Designs

O.5 Optoelectronic Systems - Improvement in manufacturing and systems integration of optoelectronic systems in the following areas: Optical Sources - lasers, VCSELs; Optical Detectors; Optical Channels/Fibers; Optical Interconnects

O.6 RF Systems - Manufacturing and systems integration of RF systems in the following areas: Transceivers – Antennas; Microwave Discrete Circuits; Microwave Monolithic Integrated Circuits; Microwave Integrated Circuits

O.7 MEMS Packaging - Manufacturing and systems integration of MEMS packaging in the following areas: Ceramic Packaging; Plastic Packaging; Metal Packaging – typical applications cover pressure sensors, accelerometers, and actuators

Please direct your inquiries to the appropriate Program Director:

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